ANNUAL RINGS OF GROWTH IN CARBONIFEROUS WOOD

WINIFRED GOLDRING

(WITH PLATE XIV)

In a discussion of anatomical structure and climatic evolution, JEFFREY[1] emphasizes the absence of annual rings in Cordaitean wood from the Carboniferous in latitudes south of England as indicative of uniformity of climate, in contrast with the conditions in the Triassic period, in which coniferous wood with annual rings is found as far south as Arizona. His statement is as follows:

In the Paleozoic trunks which are supplied by the geological formations of Southern Canada the organization of the wood shows great uniformity, and there are no modifications of structure which indicate any periodicity in annual conditions of growth. The truth of this statement is well illustrated by . . . . wood of a Cordaitean form from the Permo-Carboniferous of Hampton, Prince Edward Island. The presence of clear zones of periodic growth is, however, frequently found in regions of higher latitude . . . . . The next illustration shows the organization of a Carboniferous Cordaitean wood (*Mesoxylon*) from the northern part of England, and consequently of considerably higher latitude (54° N. in contrast to the 46° N., the latitute of Prince Edward Island). The annual rings in the wood from the English Carboniferous are clearly marked.

For comparison with the situation revealed by the Cordaitean wood from Northern England, a trunk from the Triassic of the southwest region of the United States (Arizona) is shown . . . . . The annual rings are not so distinct in the photomicrograph as they appear on the weathered end of the actual petrified specimen. It will be clear from the information supplied in this case that as far south as Arizona in the Triassic annual rings were more or less clearly marked. A noteworthy variation in the annual temperature in that somewhat remote epoch is thus indicated.[2] This situation presents an interesting contrast to the climatic conditions which prevailed in the region of Prince Edward Island toward the end of the Paleozoic. If the situation be summarized, it is clear that in the later Paleozoic the difference between 46° N. and 54° N. means the presence in the higher latitude of annual rings and their absence in the lower one. On the other hand, in the beginning of the Mesozoic (the Triassic), even at a distance of 10° south of the latitude of Prince Edward Island, annual rings were quite clearly developed.

[1] JEFFREY, E. C., The anatomy of woody plants. 1917.

[2] This might indicate variation in moisture instead of temperature.

Recently BERRY has come into possession of part of a trunk of *Cordaites* from Bartlesville, Oklahoma, which shows annual rings of growth quite distinctly. The specimen comes from the Upper Pennsylvanian (below the Americus formation). The location is described as follows in a letter from the donor, Mr. GILBERT HART:

As near as I can judge, the trees are confined to a rather limited belt, and are rather common there. . . . . The trees are found always below the Americus. As yet I have seen none surely in place; the nearest to the original position was in talus just below the first heavy limestone in the Admire formation. I feel sure that this is almost the true horizon.

The latitude of Bartlesville, Oklahoma, is 36°45′ N., about 10° south of the Prince Edward Island locality, practically the latitude of the Triassic forest of Arizona, where is found the coniferous wood showing more or less clearly marked annual rings. If the occurrence in Arizona argues for a "noteworthy variation in the annual temperature" in this area during the Triassic, then the annual rings in the trees of the Oklahoma forest would indicate the same for the end of the Carboniferous.

So far as known, the Oklahoma forest is the most southern occurrence of Carboniferous wood with annual rings of growth which has been noted; but such occurrences have previously been noted in wood from the Carboniferous, or earlier, in latitudes as far (or farther) south as Prince Edward Island. PENHALLOW,[3] in his discussion of North American species of *Dadoxylon*, states that, of the eighteen species now entitled to recognition, three show more or less clearly defined growth rings, while in the remaining fifteen they are obscure or obsolete. Of the species discussed in this paper one, *Cordaites pennsylvanicum* (Dawson) Penhallow, showing distinct growth rings, comes from the Carboniferous at Pittsville, Pennsylvania (41°30′ N.). Two other species, *C. Hamiltonense* Penhallow and *C. Clarkii* Dawson from the Devonian (Genesee shales) of Ontario County, New York (43°N.), show obscure growth rings. In the second species, however, they are, sometimes wanting. Both the Pennsylvanian and New York localities are much farther south than the English (54° N.) or Prince Edward Island (46° N.) areas.

[3] Trans. Roy. Soc. Can. **6**:57. 1900.

KNOWLTON,[4] in a survey of all the described species of *Cordaites* and *Dadoxylon*, describes twenty-four species as showing growth rings either distinctly or indistinctly. Of these, *Cordaites ouangondianum* Dawson from the Middle Devonian of New Brunswick and *Dadoxylon* (*Cordaites*) *annulatum* Dawson of the Middle Carboniferous of Nova Scotia must be excluded because the original descriptions were based on a complete misinterpretation of structural features (PENHALLOW, p. 56). Of the other species, nine are from the Carboniferous, the remainder from the Permian. Of the Carboniferous species, seven are from latitudes south of England, and of these four species are from latitudes as far, or practically as far south as Prince Edward Island, as follows: Nova Scotia (46° N.), three species; Niederburbach in Upper Alsace (47°45′ N.), one species showing distinct rings of growth. Most of the Permian species range in latitudes from 50°15′ N. to 51° N., but one species, with distinct growth rings, is recorded from Val d' Ajol, Department of Upper Sâone, France (47°40′ N.).

These data show that the extreme southern extension of a variable annual temperature in the Triassic period is not particularly remarkable. As far back as the Middle Devonian (Genesee) there must have been noticeable variations in climate in fairly low latitudes, in order to effect even the slight variations in wood formation noted, while in the Carboniferous the development of distinctly marked annual rings of growth indicates a pronounced seasonal variation in the climate of that period, even in far southern latitudes. This is also shown, but less markedly, in the Permian.

The specimen from the Upper Carboniferous of Bartlesville, Oklahoma, represents part of a trunk of a tree of considerable size, for in the section of trunk preserved, a radius of 5.5 inches of wood is shown with neither pith on one side nor cortex on the other. PENHALLOW gave the name *Cordaites recentium* to an undescribed species from the Permian or Permo-Carboniferous of Prince Edward Island, which Sir WILLIAM DAWSON had regarded as related, if not identical with *C. materiarium* Dawson from the Upper Carboniferous of Nova Scotia, Newfoundland, Illinois, etc. The species was not figured, but after a comparison of PENHALLOW's description

[4] Proc. U.S. Nat. Museum. 12:601–617. 1890.

with thin sections of the Oklahoma trunk, there seems no real justification for a separation of the latter from the Prince Edward Island species, in spite of the great distance between the two localities. The original description follows:

Cordaites recentium (Dawson) Penhallow

Transverse.—Tracheids 47×53 μ broad, the walls much reduced by decay.

Radial.—Ray cells all of one kind, about equal to two tracheids; the lateral walls with round pits about one (?) per tracheid; the cells conspicuously narrower at the ends.

Bordered pits in a single row, compact, large, compressed and transversely oval or oblong, 15.6×22 μ, the orifice very variable, from oblong to round, often eccentric, but typically round and central. When distant the pits are round and smaller.

Tangential.—Rays medium, 1–2 seriate, the very broad cells 41 μ, thin-walled, round and squarish.

Penhallow makes no mention of the occurrence of annual rings of growth, which are very distinctly shown in the Oklahoma specimen. The rings of growth shown in the transverse section are variable in width; one has a width of 3 mm., a second 8 mm., and 6 mm. of a third are shown. The growth rings show very well on the weathered surface of the trunk; in one place the growth rings have the following successive widths: 3 mm., 3.5 mm., 7.5 mm., 3.5 mm., 3 mm., 3.5 mm., 3 mm., etc.; in another place, 4 mm., 4 mm., 4 mm., etc. On the whole, therefore, the growth rings are of about even width.

The bordered pits in a single row on the radial walls of the tracheids distinguish *C. recentium* from *C. materiarium*, in which the pits are numerous throughout the tracheids, chiefly in two, sometimes in three or four rows. The ray cells are narrowed at the ends, but not conspicuously so, and are equal to 2–6 tracheids in the Oklahoma specimen, as in *C. materiarium*, the longer cells being more frequent. The pits on the lateral walls are round, and so far as can be ascertained, one to a tracheid as described by Penhallow. The rays are numerous and in general very long, composed of from two to at least forty-seven cells superimposed upon each other and tapering toward each end. The rays are described as "1–2 seriate," but usually they are uniseriate. In no place have they been found biseriate throughout. The biseriality is usually confined to the middle of the ray, although it may also occur at one or both ends; often it is confined only to the depth of one to three cells.

C. recentium resembles *Dadoxylon antiquum* Dawson (Upper Carboniferous of Nova Scotia) in the possession of bordered pits in one row, but differs from it, among other things, in the possession of practically uniseriate rays, whereas *D. antiquum* has multiseriate rays two to four cells wide. *D. prosseri* Penhallow (Permian, Chase County, Kansas) has numerous uniseriate rays (biseriate in part), but the bordered pits are smaller, and although they may occur in one row on the tracheid walls, are chiefly in two rows.

Photographic reproductions of transverse, radial, and tangential sections of the wood of this species are shown in the accompanying plate.

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EXPLANATION OF PLATE XIV

FIG. 1.—Transverse section, $\times 3$.

FIG. 2.—Transverse section, $\times 50$.

FIG. 3.—Tangential section, $\times 50$.

FIG. 4.—Radial section, $\times 50$.